

Student ID: _____

CS 151 Midterm

Name : _____ , _____
(Last Name) (First Name)

Student ID : _____

Signature : _____

Instructions:

1. Please verify that your paper contains **13 pages** including this cover.
2. Write down your Student-Id on the top of each page of this quiz.
3. This exam is **closed book**. No notes or other materials are permitted.
4. Total credits of this midterm are **80 points**.
5. To receive credit you must show your work clearly.
6. **Re-grade requests will not be entertained unless you write clearly.**
7. Calculators are **NOT** allowed.
8. If necessary, state your assumptions clearly

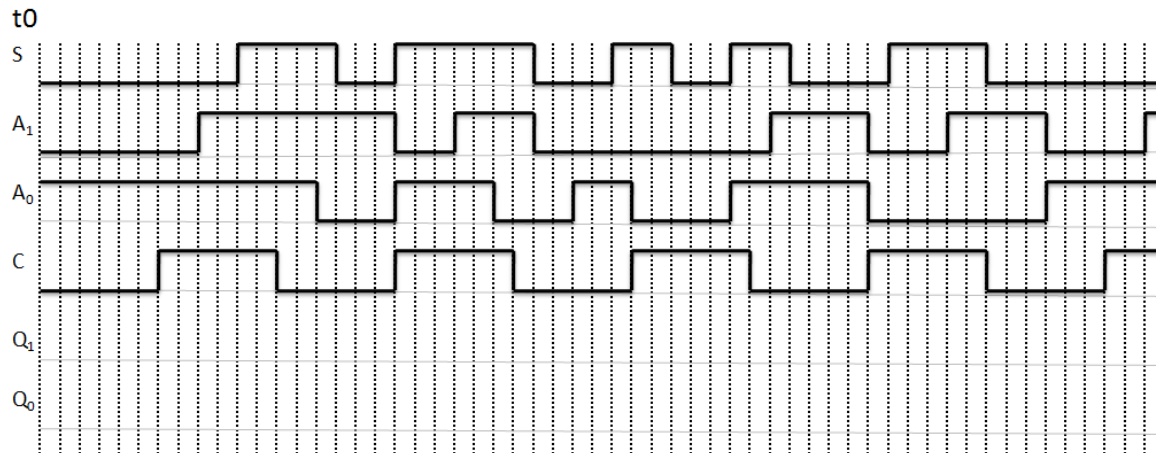
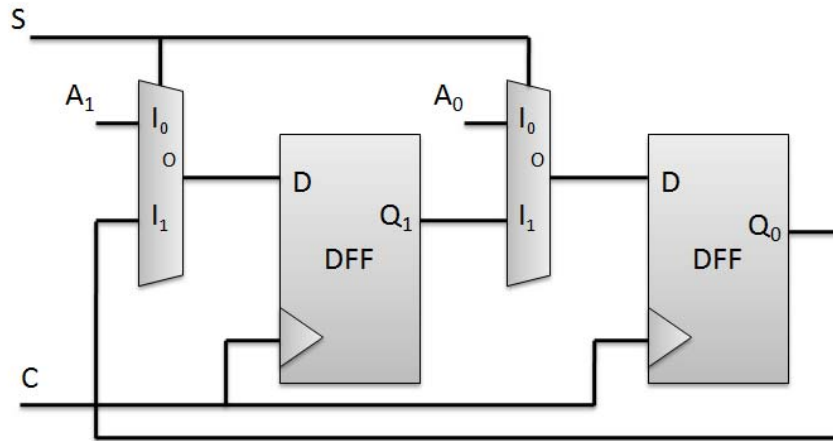
Student ID: _____

Q1: [Sequential Circuit Timing Analysis]

[10 points]

The circuit below shows a sequential circuit using D Flip Flops, and Multiplexers that A_1 , A_0 , and S are the inputs of the circuit, and Q_1 is 0, Q_0 is 1 when time equals 0 (t_0), show the timing diagram for Q_1 and Q_0 .

NOTE: You can assume that gate delay is negligible.



Student ID: _____

Q2: [ALU]

[20 points]

We are going to design a 4-bit Arithmetic Unit (AU) with the following functional table:

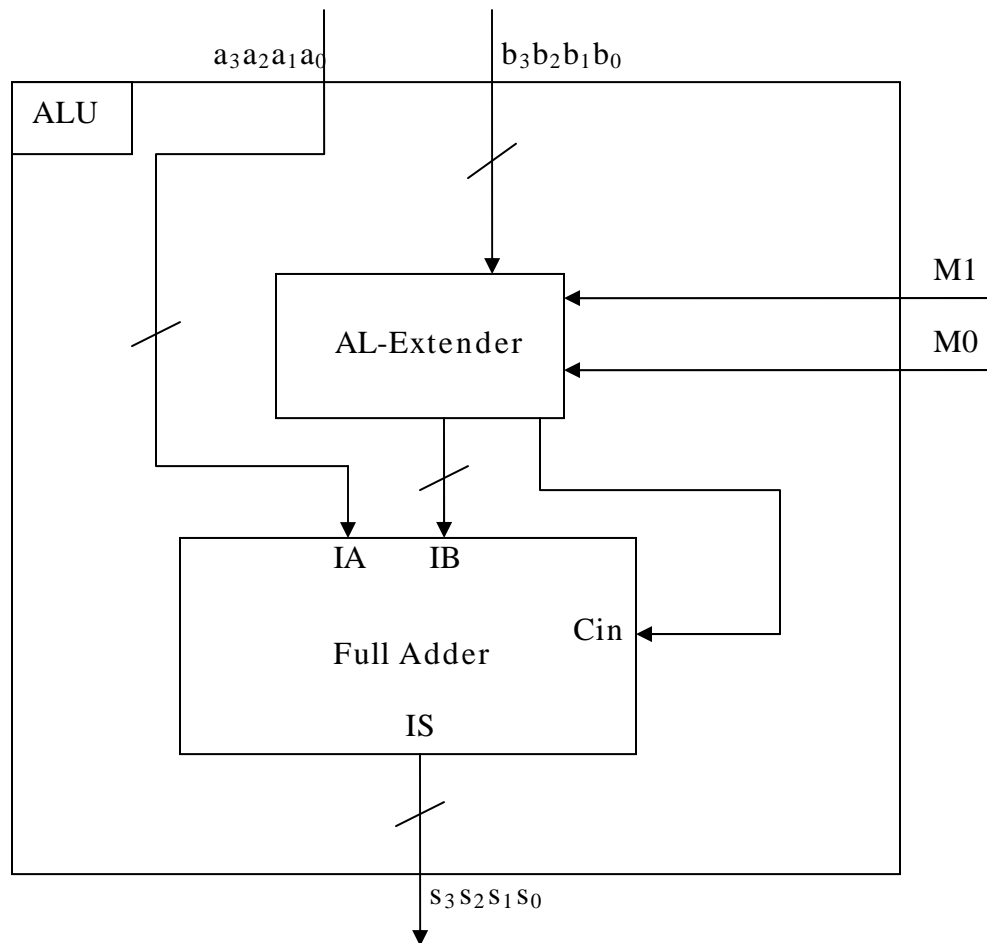
M1	M0	Function Name	F(A,B)
0	0	if(A/4==0) add B to A; else subtract B from A	if(A/4==0) $S = A + B$; else $S = A - B$
0	1	if(A<B) add A to B times 8; else add A to B divided 4	if(A<B) $S = A + (B * 8)$; else $S = A + (B / 4)$
1	0	Increment A by 4	$S = A + 4$
1	1	Add 1 to A+B * 8	$S = A + (B * 8) + 1$

Both A and B are 4-bit binary unsigned numbers a₃a₂a₁a₀ and b₃b₂b₁b₀.

M1, M0 are the control inputs to this AU. Although B is the only input register to the AL-Extender unit, if you need to, you can also connect register A to the AL-Extender.

In this question you are required to design the logic inside AL-Extender using JUST Comparators, and Multiplexers if needed.

Hint: Although the inputs and outputs are unsigned numbers, you can use 2's complement arithmetic within the design.



Student ID: _____

<This page is intentionally left blank>

Student ID: _____

<This page is intentionally left blank>

Student ID: _____

Q3: [Counter Application]

[15 points]

Using **only a 3-bit up** binary counter, you are going to design a mod-8 specific sequence whose output (denoted by **MOD8**) is 1 when the equals 0, otherwise it outputs a 0. The sequence is defined below in Q 3a. any of the following components (**Specify the bit widths, and name all inputs/outputs**):

- 1) Adders
- 2) Shifters
- 3) Comparators
- 4) Multiplexers

Make sure you answer both parts 3a, and 3b.

3a. Using the 3-bit up binary counter, create a counter that generates the following sequence [10 points]:

$2 \rightarrow 4 \rightarrow 6 \rightarrow 8 \rightarrow 10 \rightarrow 12 \rightarrow 14 \rightarrow 16 \rightarrow 2 \rightarrow 4 \dots$

Student ID: _____

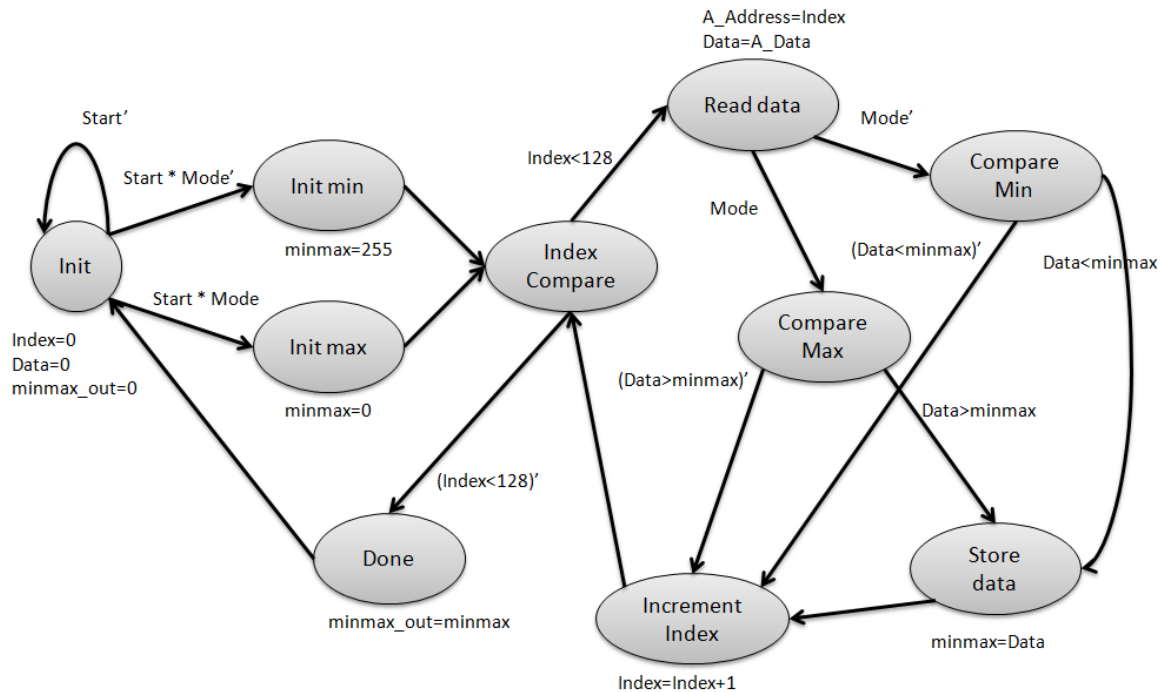
<This page is intentionally left blank>

Student ID: _____

3b. Using the counter designed in part 3a design a mod-8 counter whose output (denoted by MOD8) is 1 when the sequence value mod 8 equals 0, otherwise it outputs a 0. [5 points]

Q4: [RTL design]**[35 points]**

The following high-level state machine has the task of finding either the minimum or the maximum among an array of 128 elements depending on the mode selected (Mode = 0 = find the minimum, and Mode = 1 = find the maximum). A_Data is an 8-bit input, A_Address is an 8-bit output, and minmax_out is the final 8-bit (minimum or maximum) output value. Data and minmax are both 8-bit internal registers. All inputs/outputs are unsigned. The Start input drives the circuit to start the execution of the task. Use this state machine to answer the following questions:



Student ID: _____

4a. Design the data-path for this system. [15 points]

Please note that the initial value for the minmax register depends on the Mode, if the Mode = 0, minmax is initialized to 0, if the Mode = 1, minmax is

Hint: Your minmax register will have at most 2 inputs.

You may use any of the following components:

- 1) Registers
- 2) Adders
- 3) Comparators
- 4) Multiplexers

Student ID: _____

4b. Design the interface of the system and the interface between the controller and the datapath. [5 points]

Student ID: _____

4c. Design the FSM of the controller. [15 points]

HINT: There is no timing issue for this system so you do not have to consider timing issues in designing the controller's FSM.

Student ID: _____

<This page is intentionally left blank>